TECHNICAL MEMORANDUM

DATE: October 31, 2017

TO: Peter Dane
City of Redmond

FROM: Amy Wasserman
TENW

SUBJECT: NE 51st Street & 154th Ave NE Improvements
Supplemental Signal Warrant Analysis Assessment
TENW Project No. 5288

This supplemental technical memorandum documents an updated signal warrant analysis for the intersection of NE 51st Street/154th Ave NE (see vicinity map in Attachment A). This memorandum is a supplement to the updated traffic operations assessment for the NE 51st Street corridor dated February 17, 2017.

Findings and Conclusions

Of the four signal warrants analyzed at the intersection of NE 51st Street/154th Ave NE, only Warrant 3, (Peak Hour) is met under existing PM peak hour conditions.

In order for Warrant 1 (Eight-Hour Vehicular Volume) and Warrant 2 (Four-Hour Vehicular Volume) to be met, the volumes at NE 51st Street/154th Ave NE would need to increase significantly (by approximately 20 percent to over 100 percent) depending on the Warrant evaluated.

Because of the close access spacing and heavy peak hour volumes, the NE 51st Street corridor would likely be impacted by the addition of a traffic signal at NE 51st Street/154th Ave NE, particularly as it relates to vehicular delays and queueing.

The intersection of NE 51st Street/154th Ave NE can accommodate a future traffic signal installation, should one be warranted at a future date.

Scope of Work

The scope of this supplemental analysis was confirmed through correspondence with City of Redmond staff. Based on this correspondence, the following items are included in this supplemental analysis for the intersection of NE 51st Street/154th Ave NE:

1. Documentation of signal warrant analysis of the following warrants for 2016/2017 existing conditions:
   - Warrant 1 – Four-Hour Vehicular Volume
   - Warrant 2 – Eight-Hour Vehicular Volume
   - Warrant 3 – Peak Hour Volume
   - Warrant 7 – Crash Experience
2. Qualitative discussion of future volumes needed to meet signal warrants (Warrants 1, 2, and 3 only).
3. Qualitative discussion of feasibility of traffic signal at NE 51st Street/154th Ave NE and potential impacts to NE 51st Street corridor.

4. Documentation of potential to build out intersection of NE 51st Street/154th Ave NE to accommodate a future traffic signal.

Signal Warrant Analysis

A traffic signal warrant analysis was conducted at the intersection of NE 51st Street/154th Ave NE based on traffic signal warrants as outlined in the US Department of Transportation/Federal Highway Administration, *Manual on Uniform Traffic Control Devices* (MUTCD), 2009 Edition. Of the eight signal warrants outlined in the MUTCD, Warrant 1 (Eight-Hour Volume), Warrant 2 (Four-Hour Volume), Warrant 3 (Peak Hour Volume), and Warrant 7 (Crash Experience) were analyzed.

The volume criteria used in the signal warrant analysis was based on the assumption of a 2-lane approach on the minor street (154th Ave NE) and a 2-lane approach on the major street (NE 51st Street).

The traffic volumes used in the signal warrant analysis for Warrant 1 and Warrant 2 were based on the two-day average of 48-hours of weekday daily traffic counts conducted on all approaches to the intersection on Wednesday, October 3, 2017 and Thursday, October 4, 2017. The traffic volumes used in the signal warrant analysis for Warrant 3 were based on estimated 2017 PM peak hour traffic volumes that were based on turning movement counts conducted in September 2016 and increased by 2 percent to account for one year of background growth on the major street through movements. The raw daily and peak hour traffic volumes are included in Attachment B.

The collision history used for Warrant 7 was provided by WSDOT for the most recent 3-year period from January 1, 2014 to December 31, 2016. The detailed collision history is included in Attachment C.

The results of the signal warrant analysis are summarized in Table 1. The detailed signal warrant analysis worksheets are included in Attachment D.

Table 1
Signal Warrant Analysis Results at NE 51st St/154th Ave NE

Warrant Evaluated	2016/2017 Existing Conditions
Warrant 1 – Eight-Hour Vehicular Volume[1]	
Condition A (Minimum Vehicular Volume)	NO
Condition B (Interruption of Continuous Traffic)	NO
80% of Condition A and Condition B	NO
Warrant 1 Met?	**NO**
Warrant 2 – Four-Hour Vehicular Volume	
Warrant 2 Met?	**NO**
Warrant 3 – Peak Hour (PM Peak Hour)[2]	
Condition A (Delay Calculations)	NO
Condition B (graph)	YES
Warrant 3 Met?	**YES**
Warrant 7 – Crash Experience	
Warrant 7 Met?	**NO**

1. Warrant 1 is met if either Condition A or Condition B is met.
2. Warrant 3 is met if either Condition A or Condition B is met.

As shown in Table 1, of the four signal warrants analyzed, only Warrant 3 (Peak Hour) is met under existing PM peak hour conditions at the intersection of NE 51st Street/154th Ave NE. The peak hour warrant (Warrant 3) is met if either Condition A (delay calculations) or Condition B (graph) is met and Condition B is met.

Per MUTCD, the peak hour signal warrant (Warrant 3) shall only be applied in unusual cases which may include, but are not limited to office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.

Traffic Volumes Required to Meet Signal Warrants

In order for the intersection of NE 51st Street/154th Ave NE to meet Warrant 1 (Eight-Hour Vehicular Volume) and Warrant 2 (Four-Hour Vehicular Volume), the minor street volumes on 154th Ave NE and the major street volumes on NE 51st Street would both need to increase significantly (by approximately 20 percent to over 100 percent) depending on the Warrant evaluated.

The major street volumes on NE 51st Street could potentially increase by approximately 10 to 20 percent with buildout of the following Development Agreements in the Overlake area:

- Remainder of Microsoft North Campus Development Agreement (Building 81)
- Remainder of Microsoft Main Campus Master Plan (Development Agreement)
- RedWest South (Development Agreement II)
- Overlake Village Esterra Park (Development Agreement)

However, potential buildout of the above Development Agreements would not be expected to increase the minor street volumes on 154th Ave NE. Therefore, it is unlikely that Warrant 1 (Eight-Hour Vehicular Volume) or Warrant 2 (Four-Hour Vehicular Volume) would ever be met in the future, even with potential buildout of the remaining Development Agreements in the Overlake area.

Feasibility of a Traffic Signal

The existing two-way stop controlled intersection of NE 51st Street/154th Ave NE is located approximately halfway (~500 feet from centerline to centerline) from the existing signalized intersections of NE 51st Street/SR-520 Eastbound Ramps and NE 51st Street/156th Ave NE.

The US Department of Transportation/Federal Highway Administration (USDOT FHWA) states that:

> *"Increasing the distance between traffic signals improves the flow of traffic on major arterials, reduces congestion, reduces the incidence of collisions, and improves air quality for heavily traveled corridors. The appropriate spacing between signals for a particular corridor depends greatly upon the speed and flow of traffic, but anything greater than two signals per mile has a significant impact on congestion and safety."*

If a traffic signal were to be installed at the intersection of NE 51st Street/154th Ave NE, there would be 3 signals within approximately 0.2 miles on a high-volume corridor. Because of the close access spacing and heavy peak hour volumes, the NE 51st Street corridor would likely be impacted by the addition of a traffic signal, particularly as it relates to vehicular delays and queueing. The intersection of NE 51st Street/154th Ave NE would likely operate at an acceptable Level of Service (LOS D or better) as a signal under 2017 existing AM and PM peak hour conditions with the NE 51st Street Improvements project (construct opposing eastbound and westbound left-turn lanes). However, it is possible that the 95th percentile queues in the eastbound and westbound directions may extend beyond the adjacent intersections (the SR 520 Eastbound Ramps and 156th Ave NE) during the AM and/or PM peak hours.

Buildout to Accommodate a Future Traffic Signal

The intersection of NE 51st Street/154th Ave NE can accommodate a future traffic signal installation, should one be warranted at a future date. The NE 51st Street Improvements project will construct opposing eastbound and westbound left-turn lanes that will accommodate future protected or protected/permissive left-turn movements.

The NE 51st Street Improvements project will also install spare conduit crossings on the west leg of NE 51st Street, as well as on the north and south legs of 154th Ave NE. The spare conduit crossings can accommodate a future signal installation, if necessary.

If you have any questions, please contact me at (425) 250-0579 or amy@tenw.com.

cc: Ray Berntsen, Huitt-Zollars
Leslie-Ann Jorge, Huitt-Zollars
Ashraf Habbak, City of Redmond
Chris Bicket, TENW
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Attachments

ATTACHMENT A

Site Vicinity Map

N

NOT TO SCALE

Attachment A: Site Vicinity Map

ATTACHMENT B

48-hour Traffic Volumes

Date Start: 03-Oct-17
Date End: 04-Oct-17
NE 51ST ST W/O 154TH AVE NE

Start Time	03-Oct-17 Tue	EB								
12:00 AM		19								
01:00		12								
02:00		11								
03:00		3								
04:00		14								
05:00		51								
06:00		170								
07:00		561								
08:00		1086								
09:00		**1338**								
10:00		781								
11:00		351								
12:00 PM		381								
01:00		359								
02:00		342								
03:00		390								
04:00		474								
05:00		**705**								
06:00		575								
07:00		285								
08:00		203								
09:00		140								
10:00		113								
11:00		36								
Total		8400								
AM Peak	-	09:00	-	-	-	-	-	-	-	-
Vol.	-	1338	-	-	-	-	-	-	-	-
PM Peak	-	17:00	-	-	-	-	-	-	-	-
Vol.	-	705	-	-	-	-	-	-	-	-

Date Start: 03-Oct-17
Date End: 04-Oct-17
NE 51ST ST W/O 154TH AVE NE

Start Time	04-Oct-17 Wed	EB								
12:00 AM		22								
01:00		12								
02:00		14								
03:00		4								
04:00		27								
05:00		59								
06:00		166								
07:00		552								
08:00		1064								
09:00		**1333**								
10:00		761								
11:00		351								
12:00 PM		376								
01:00		485								
02:00		336								
03:00		368								
04:00		462								
05:00		**637**								
06:00		509								
07:00		290								
08:00		214								
09:00		145								
10:00		79								
11:00		44								
Total		8310								
AM Peak	-	09:00	-	-	-	-	-	-	-	-
Vol.	-	1333	-	-	-	-	-	-	-	-
PM Peak	-	17:00	-	-	-	-	-	-	-	-
Vol.	-	637	-	-	-	-	-	-	-	-
Grand Total		16710								
ADT		ADT 8,355		AADT 8,355						

Date Start: 03-Oct-17
Date End: 04-Oct-17
154TH AVE NE N/O NE 51ST ST

Start Time	03-Oct-17 Tue	SB								
12:00 AM		0								
01:00		0								
02:00		0								
03:00		0								
04:00		1								
05:00		1								
06:00		2								
07:00		12								
08:00		13								
09:00		**25**								
10:00		18								
11:00		8								
12:00 PM		16								
01:00		18								
02:00		11								
03:00		20								
04:00		32								
05:00		**74**								
06:00		42								
07:00		20								
08:00		14								
09:00		9								
10:00		11								
11:00		1								
Total		348								
AM Peak	-	09:00	-	-	-	-	-	-	-	-
Vol.	-	25	-	-	-	-	-	-	-	-
PM Peak	-	17:00	-	-	-	-	-	-	-	-
Vol.	-	74	-	-	-	-	-	-	-	-

Date Start: 03-Oct-17
Date End: 04-Oct-17
154TH AVE NE N/O NE 51ST ST

Start Time	04-Oct-17 Wed	SB								
12:00 AM		1								
01:00		0								
02:00		1								
03:00		0								
04:00		0								
05:00		3								
06:00		6								
07:00		14								
08:00		15								
09:00		10								
10:00		**21**								
11:00		14								
12:00 PM		9								
01:00		27								
02:00		18								
03:00		25								
04:00		31								
05:00		**58**								
06:00		23								
07:00		29								
08:00		8								
09:00		12								
10:00		4								
11:00		2								
Total		331								
AM Peak	-	10:00	-	-	-	-	-	-	-	-
Vol.	-	21	-	-	-	-	-	-	-	-
PM Peak	-	17:00	-	-	-	-	-	-	-	-
Vol.	-	58	-	-	-	-	-	-	-	-
Grand Total		679								
ADT		ADT 340		AADT 340						

Date Start: 03-Oct-17
Date End: 04-Oct-17
NE 51ST ST E/O 154TH AVE NE

Start Time	03-Oct-17 Tue	WB								
12:00 AM		20								
01:00		10								
02:00		9								
03:00		8								
04:00		16								
05:00		54								
06:00		152								
07:00		334								
08:00		**482**								
09:00		461								
10:00		224								
11:00		251								
12:00 PM		275								
01:00		288								
02:00		290								
03:00		442								
04:00		616								
05:00		**674**								
06:00		627								
07:00		293								
08:00		150								
09:00		89								
10:00		56								
11:00		24								
Total		5845								
AM Peak	-	08:00	-	-	-	-	-	-	-	-
Vol.	-	482	-	-	-	-	-	-	-	-
PM Peak	-	17:00	-	-	-	-	-	-	-	-
Vol.	-	674	-	-	-	-	-	-	-	-

Date Start: 03-Oct-17
Date End: 04-Oct-17
NE 51ST ST E/O 154TH AVE NE

Start Time	04-Oct-17 Wed	WB								
12:00 AM		17								
01:00		5								
02:00		8								
03:00		6								
04:00		19								
05:00		53								
06:00		175								
07:00		329								
08:00		**451**								
09:00		438								
10:00		253								
11:00		282								
12:00 PM		291								
01:00		321								
02:00		305								
03:00		434								
04:00		588								
05:00		**693**								
06:00		479								
07:00		300								
08:00		135								
09:00		90								
10:00		41								
11:00		29								
Total		5742								
AM Peak	-	08:00	-	-	-	-	-	-	-	-
Vol.	-	451	-	-	-	-	-	-	-	-
PM Peak	-	17:00	-	-	-	-	-	-	-	-
Vol.	-	693	-	-	-	-	-	-	-	-
Grand Total		11587								
ADT		ADT 5,794		AADT 5,794						

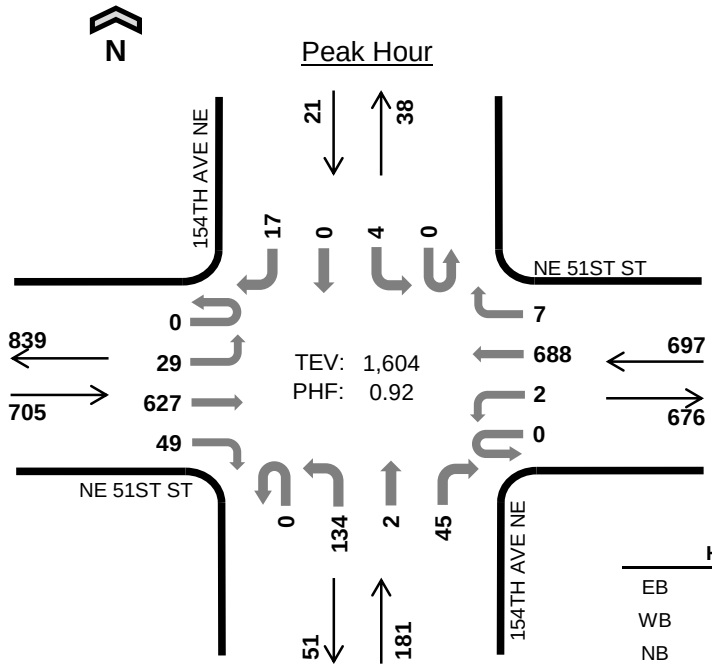
Date Start: 03-Oct-17
Date End: 04-Oct-17
154TH AVE NE S/O NE 51ST ST

Start Time	03-Oct-17 Tue	NB								
12:00 AM		9								
01:00		7								
02:00		13								
03:00		1								
04:00		0								
05:00		5								
06:00		23								
07:00		33								
08:00		37								
09:00		47								
10:00		62								
11:00		**77**								
12:00 PM		121								
01:00		72								
02:00		96								
03:00		134								
04:00		177								
05:00		**249**								
06:00		210								
07:00		97								
08:00		41								
09:00		27								
10:00		13								
11:00		4								
Total		1555								
AM Peak	-	11:00	-	-	-	-	-	-	-	-
Vol.	-	77	-	-	-	-	-	-	-	-
PM Peak	-	17:00	-	-	-	-	-	-	-	-
Vol.	-	249	-	-	-	-	-	-	-	-

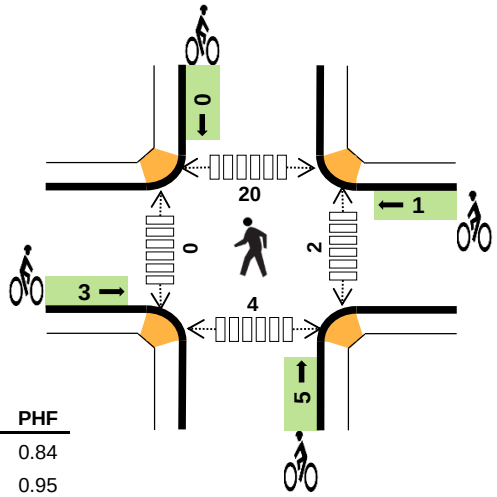
Date Start: 03-Oct-17
Date End: 04-Oct-17
154TH AVE NE S/O NE 51ST ST

Start Time	04-Oct-17 Wed	NB								
12:00 AM		8								
01:00		3								
02:00		11								
03:00		1								
04:00		0								
05:00		6								
06:00		3								
07:00		41								
08:00		48								
09:00		47								
10:00		44								
11:00		**99**								
12:00 PM		96								
01:00		91								
02:00		111								
03:00		101								
04:00		201								
05:00		**278**								
06:00		206								
07:00		73								
08:00		44								
09:00		18								
10:00		8								
11:00		16								
Total		1554								
AM Peak	-	11:00	-	-	-	-	-	-	-	-
Vol.	-	99	-	-	-	-	-	-	-	-
PM Peak	-	17:00	-	-	-	-	-	-	-	-
Vol.	-	278	-	-	-	-	-	-	-	-
Grand Total		3109								
ADT		ADT 1,554		AADT 1,554						

154TH AVE NE
NE 51ST ST



Date: Thu, Sep 29, 2016
Count Period: 4:00 PM to 6:00 PM
Peak Hour: 5:00 PM to 6:00 PM



	HV %:	PHF
EB	0.7%	0.84
WB	0.6%	0.95
NB	0.0%	0.71
SB	0.0%	0.88
TOTAL	0.6%	0.92

Two-Hour Count Summaries

Interval Start	NE 51ST ST Eastbound				NE 51ST ST Westbound				154TH AVE NE Northbound				154TH AVE NE Southbound				15-min Total	Rolling One Hour
	UT	LT	TH	RT	UT	LT	TH	RT	UT	LT	TH	RT	UT	LT	TH	RT		
4:00 PM	0	4	83	10	0	1	142	1	0	23	0	9	0	1	0	4	278	0
4:15 PM	0	5	103	16	0	2	129	2	0	27	0	6	0	2	0	5	297	0
4:30 PM	0	7	114	12	0	1	133	0	0	20	0	7	0	0	0	0	294	0
4:45 PM	0	6	143	13	0	1	161	0	0	27	2	9	0	0	0	2	364	1,233
5:00 PM	**0**	**3**	**130**	**16**	**0**	**1**	**156**	**2**	**0**	**50**	**0**	**14**	**0**	**2**	**0**	**2**	**376**	1,331
5:15 PM	**0**	**7**	**194**	**10**	**0**	**1**	**177**	**1**	**0**	**33**	**0**	**7**	**0**	**1**	**0**	**5**	**436**	1,470
5:30 PM	**0**	**8**	**147**	**17**	**0**	**0**	**173**	**2**	**0**	**29**	**0**	**18**	**0**	**1**	**0**	**5**	**400**	1,576
5:45 PM	**0**	**11**	**156**	**6**	**0**	**0**	**182**	**2**	**0**	**22**	**2**	**6**	**0**	**0**	**0**	**5**	**392**	**1,604**
Count Total	0	51	1,070	100	0	7	1,253	10	0	231	4	76	0	7	0	28	2,837	0
Peak Hour	**0**	**29**	**627**	**49**	**0**	**2**	**688**	**7**	**0**	**134**	**2**	**45**	**0**	**4**	**0**	**17**	**1,604**	**0**

Note: Two-hour count summary volumes include heavy vehicles but exclude bicycles in overall count.

Interval Start	Heavy Vehicle Totals					Bicycles					Pedestrians (Crossing Leg)				
	EB	WB	NB	SB	Total	EB	WB	NB	SB	Total	East	West	North	South	Total
4:00 PM	0	1	0	0	*1*	1	0	0	0	*1*	0	0	4	4	*8*
4:15 PM	2	1	0	0	*3*	0	0	0	0	*0*	1	1	5	2	*9*
4:30 PM	3	1	0	0	*4*	0	0	0	1	*1*	0	0	4	4	*8*
4:45 PM	2	1	0	0	*3*	0	0	0	0	*0*	1	2	4	3	*10*
5:00 PM	**1**	**1**	**0**	**0**	***2***	**0**	**0**	**1**	**0**	***1***	**0**	**0**	**4**	**0**	*4*
5:15 PM	**1**	**1**	**0**	**0**	***2***	**1**	**0**	**3**	**0**	***4***	**0**	**0**	**8**	**1**	*9*
5:30 PM	**2**	**0**	**0**	**0**	***2***	**2**	**1**	**1**	**0**	***4***	**1**	**0**	**3**	**1**	*5*
5:45 PM	**1**	**2**	**0**	**0**	***3***	**0**	**0**	**0**	**0**	***0***	**1**	**0**	**5**	**2**	***8***
Count Total	12	8	0	0	*20*	4	1	5	1	*11*	4	3	37	17	*61*
Peak Hour	**5**	**4**	**0**	**0**	***9***	**3**	**1**	**5**	**0**	***9***	**2**	**0**	**20**	**4**	***26***

Mark Skaggs: (425) 250-0777 mark.skaggs@idaxdata.com

ATTACHMENT C

Collision History

OFFICER REPORTED CRASHES THAT OCCURRED on OR in the vicinity of THE FOLLOWING ROAD SEGMENTS IN THE CITY OR REDMOND
NE 51st ST at 154th AVE

1/1/2014 - 12/31/2016

Under 23 U.S. Code § 409 and 23 U.S. Code § 148, safety data, reports, surveys, schedules, lists compiled or collected for the purpose of identifying, evaluating, or planning the safety enhancement of potential crash sites, hazardous roadway conditions, or railway-highway crossings are not subject to discovery or admitted into evidence in a Federal or State court proceeding or considered for other purposes in any action for damages arising from any occurrence at a location mentioned or addressed in such reports, surveys, schedules, lists, or data.

JURISDICTION	PRIMARY TRAFFICWAY	BLOCK NUMBER	INTERSECTING TRAFFICWAY	DATE	TIME	MOST SEVERE INJURY TYPE	# INJ	# FAT	# VEH	# PEDS	# PEDAL	VEHICLE 1 TYPE	VEHICLE 2 TYPE	FIRST COLLISION TYPE / OBJECT STRUCK	VEH 1 ACTION	VEH 2 ACTION	MV DRIVER CONT CIRC 1 (UNIT 1)	MV DRIVER CONT CIRC 1 (UNIT 2)	VEH 1 COMP DIR FROM	VEH 1 COMP DIR TO	VEH 2 COMP DIR FROM	VEH 2 COMP DIR TO
City Street	NE 51ST ST	15400	154TH AVE NE	7/1/2014	17:59	Evident Injury	1	0	1	0	0	Motorcycle		Vehicle overturned	Slowing		Other		East	West		
City Street	NE 51ST ST	15300	154TH AVE NE	8/13/2016	14:16	No Injury	0	0	2	0	0	Passenger Car	Pickup,Panel Truck or Vanette under 10,000 lb	Entering at angle	Making Right Turn	Going Straight Ahead	Did Not Grant RW to Vehicle	None	North	West	East	West
City Street	NE 51ST ST	15300	154TH PL NE	1/8/2014	18:18	No Injury	0	0	2	0	0	Pickup,Panel Truck or Vanette under 10,000 lb	Passenger Car	From opposite direction - one left turn - one straight	Making Left Turn	Going Straight Ahead	Did Not Grant RW to Vehicle	None	East	South	West	East
City Street	NE 51ST ST	15400	154TH PL NE	6/24/2014	18:21	No Injury	0	0	2	0	0	Passenger Car	Passenger Car	From opposite direction - one left turn - one straight	Making Left Turn	Going Straight Ahead	Inattention	None	East	South	West	East

ATTACHMENT D

Signal Warrant Analysis Worksheets

Connecting Redmond
TENW Project No. 5288

Signal Warrant Analysis for NE 51st Street / 154th Ave NE
2017 Existing Conditions

Warrant 1 - Eight Hour Vehicular Volume
Condition A - Minimum Vehicular Volume

Hour Begins	Minor Approach 154th Ave NE Highest NB/SB (2)	Major Approach NE 51st St Total EB & WB (2)	MUTCD (1) Warrant 1A
6:00	13	332	
7:00	37	889	
8:00	43	1,542	
9:00	47	1,786	
10:00	53	1,010	
11:00	88	618	
12:00	109	662	
13:00	82	727	
14:00	104	637	
15:00	118	817	
16:00	189	1,070	
17:00	264	1,355	YES
18:00	208	1,095	YES
19:00	85	585	
		WARRANT MET (3) =	**NO**

Notes:
(1) MUTCD - Manual on Uniform Traffic Control Devices, 2009.
(2) Two-day average of 24-hour volumes conducted on 10/3/17 and 10/4/17.
(3) Signal warrant satisfied when traffic volumes exist for each of any 8 hours of an average day.

MUTCD Warrant Requirements

Warrant 1, Condition A: Minimum Vehicular Volume

Minimum volume of 600 vehicles per hour on 2-lane major street (both approaches) and 200 vehicles per hour on 2-lane minor street approach.

Connecting Redmond
TENW Project No. 5288

Signal Warrant Analysis for NE 51st Street / 154th Ave NE
2017 Existing Conditions

Warrant 1 - Eight Hour Vehicular Volume
Condition B - Interruption of Continuous Traffic

Hour Begins	Minor Approach 154th Ave NE Highest NB/SB (2)	Major Approach NE 51st St Total EB & WB (2)	MUTCD (1) Warrant 1B
6:00	13	332	
7:00	37	889	
8:00	43	1,542	
9:00	47	1,786	
10:00	53	1,010	
11:00	88	618	
12:00	109	662	
13:00	82	727	
14:00	104	637	
15:00	118	817	
16:00	189	1,070	YES
17:00	264	1,355	YES
18:00	208	1,095	YES
19:00	85	585	
		WARRANT MET (3) =	**NO**

Notes:
(1) MUTCD - Manual on Uniform Traffic Control Devices, 2009.
(2) Two-day average of 24-hour volumes conducted on 10/3/17 and 10/4/17.
(3) Signal warrant satisfied when traffic volumes exist for each of any 8 hours of an average day.

MUTCD Warrant Requirements

Warrant 1, Condition B: Interruption of Continuous Traffic

Minimum volume of 900 vehicles per hour on 2-lane major street (both approaches) and 100 vehicles per hour on 2-lane minor street approach.

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Signal Warrant Analysis for NE 51st Street / 154th Ave NE
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Warrant 1 - Eight Hour Vehicular Volume
Combination of Condition A and Condition B

Hour Begins	Minor Approach 154th Ave NE Highest NB/SB (2)	Major Approach NE 51st St Total EB & WB (2)	MUTCD (1)		
			Warrant 1 A/B	80% Condition A	80% Condition B
6:00	13	332			
7:00	37	889			
8:00	43	1,542			
9:00	47	1,786			
10:00	53	1,010			
11:00	88	618			
12:00	109	662			
13:00	82	727			YES
14:00	104	637			
15:00	118	817			YES
16:00	189	1,070	YES	YES	YES
17:00	264	1,355	YES	YES	YES
18:00	208	1,095	YES	YES	YES
19:00	85	585			
		WARRANT MET (3) =	**NO**		

Notes:
(1) MUTCD - Manual on Uniform Traffic Control Devices, 2009.
(2) Two-day average of 24-hour volumes conducted on 10/3/17 and 10/4/17.
(3) Signal warrant satisfied when traffic volumes exist for each of any 8 hours of an average day.

MUTCD Warrant Requirements

Warrant 1: Combination of A and B

The combination of warrants is satisfied where Condition A and Condition B are satisfied to the extent of 80 percent or more of the stated values for Condition A and Condition B.

NOTE:

This combination warrant only applies after an adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems.

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Signal Warrant Analysis for NE 51st Street / 154th Ave NE
2017 Existing Conditions

Warrant 2 - Four Hour Vehicular Volume

Hour Begins	Minor Approach 154th Ave NE Highest NB/SB (2)	Major Approach NE 51st St Total EB & WB (2)	MUTCD (1) Warrant 2
6:00	13	332	
7:00	37	889	
8:00	43	1,542	
9:00	47	1,786	
10:00	53	1,010	
11:00	88	618	
12:00	109	662	
13:00	82	727	
14:00	104	637	
15:00	118	817	
16:00	189	1,070	YES
17:00	264	1,355	YES
18:00	208	1,095	YES
17:00	85	585	
		WARRANT MET (3) =	**NO**

Notes:
(1) MUTCD - Manual on Uniform Traffic Control Devices, 2009.
(2) Two-day average of 24-hour volumes conducted on 10/3/17 and 10/4/17.
(3) Signal warrant satisfied when traffic volumes exist for each of any 4 hours of an average day.

MUTCD Warrant Requirements

Warrant 2: Four Hour Vehicular Volume

The plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher volume minor street approach (one direction only) all fall above the applicable curve in Figure 4C-1 for the existing combination of approach lanes.

Option:

If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-2 may be used in place of Figure 4C-1.

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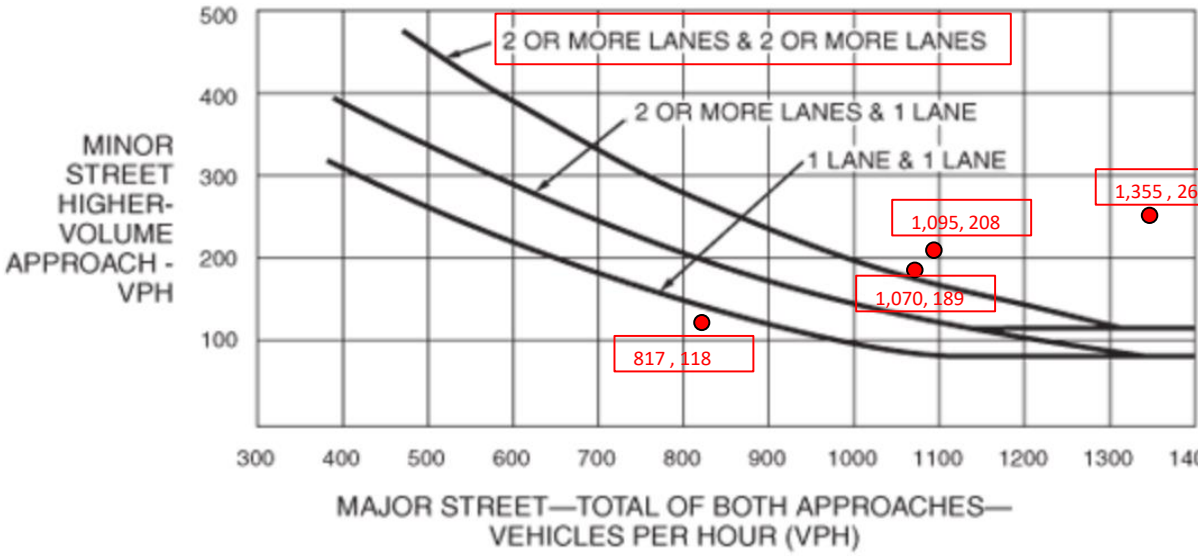
Signal Warrant Analysis for NE 51st Street / 154th Ave NE
2017 Existing Conditions

Warrant 2 - Four Hour Vehicular Volume

Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume



*Note: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.

WARRANT MET (2) =

Notes:

(1) The four highest hourly minor/major approach volumes as shown in the data for Warrant 1.

(2) The signal warrant is satisfied when the conditions given below exist for each of any 4 hours of an average day.

MUTCD Warrant Requirements

Warrant 2: Four Hour Vehicular Volume

The plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher volume minor street approach (one direction only) all fall above the applicable curve in Figure 4C-1 for the existing combination of approach lanes. On the minor street, the higher volume shall not be required to be on the same approach during each of these 4 hours.

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Signal Warrant Analysis for NE 51st Street / 154th Ave NE
2017 Existing Conditions

Warrant 3 - Peak Hour (PM Peak Hour)

Condition A

This warrant is met if all three of the following conditions exist for the same 1 hour (any four consecutive 15-minute periods) of an average day:

1. The total stopped delay experienced by the traffic on one minor-street approach (one direction only) controlled by a STOP sign equals or exceeds: 4 vehicle-hours for a one-lane approach; or 5 vehicle-hours for a two-lane approach

NE 51st St/154th Ave NE, NB approach (2 lanes)

	NB Approach		
Control Delay (sec/veh) =	23.2	sec/veh	**Based on results from HCM 6th Edition analysis
Stopped Delay (sec/veh) =	17.8	sec/veh	
Total Volume (veh/hr) =	181	veh/hour	
Vehicle-Hours =	0.90	veh-hours	
CONDITION 1 MET =	**NO**		

2. The volume on the same minor-street approach (one direction only) equals or exceeds 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour for two moving lanes.

NE 51st St/154th Ave NE, NB approach (2 lanes) =		181
CONDITION 2 MET =	**YES**	

3. The total entering volume serviced during the hour equals or exceeds 650 vehicle per hour for intersections with three approaches or 800 vehicles per hour for intersections with four or more approaches.

NE 51st St/154th Ave NE, TEV =		1,631
CONDITION 3 MET =	**YES**	

WARRANT MET =	**NO**

NOTE:

This signal warrant shall only be applied in unusual cases. Such cases include, but are not limited to, office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.

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Signal Warrant Analysis for NE 51st Street / 154th Ave NE
2017 Existing Conditions

Warrant 3 - Peak Hour
Condition B

Hour Begins	Minor Approach 154th Ave NE Highest NB/SB (2)	Major Approach NE 51st St Total EB & WB (2)	MUTCD (1) Warrant 3
6:00	13	332	
7:00	37	889	
8:00	43	1,542	
9:00	47	1,786	
10:00	53	1,010	
11:00	88	618	
12:00	109	662	
13:00	82	727	
14:00	104	637	
15:00	118	817	
16:00	189	1,070	
17:00	264	1,355	YES
18:00	208	1,095	
19:00	85	585	
		WARRANT MET (3) =	**YES**

Notes:
(1) MUTCD - Manual on Uniform Traffic Control Devices, 2009.
(2) Two-day average of 24-hour volumes conducted on 10/3/17 and 10/4/17.
(3) Signal warrant satisfied when traffic volumes exist for one hour of an average day.

MUTCD Warrant Requirements

Warrant 3: Peak Hour - Condition B

The plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher volume minor street approach (one direction only) for one hour (any four consectutive 15-minute periods) of an average day falls above the curve in Figure 4C-3 for the existing combination of approach lanes.

NOTE:

This signal warrant shall only be applied in unusual cases. Such cases include, but are not limited to, office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.

Option:

If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the itnersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-4 may be used in place of Figure 4C-3.

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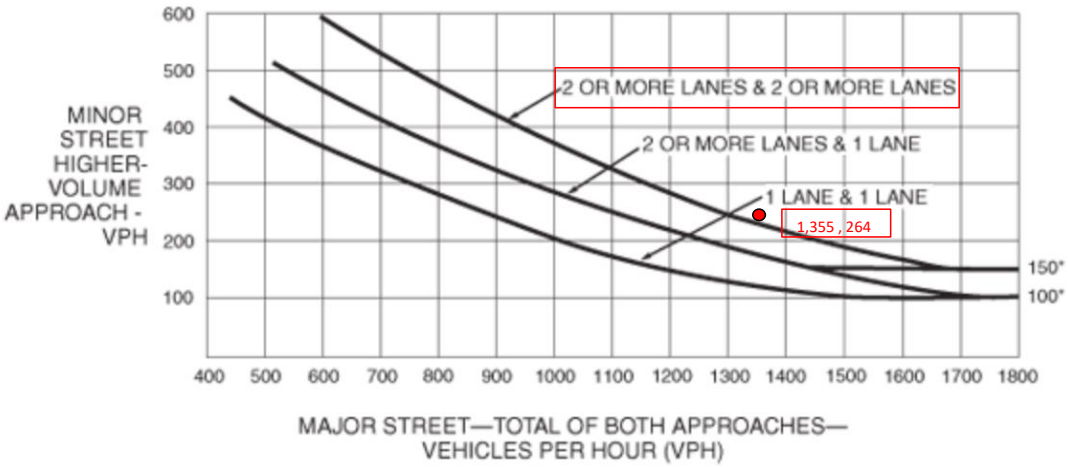
Signal Warrant Analysis for NE 51st Street / 154th Ave NE
2017 Existing Conditions

Warrant 3 - Peak Hour (PM Peak Hour)
Condition B

Figure 4C-3. Warrant 3, Peak Hour



*Note: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.

WARRANT MET (2) = YES

Notes:

(1) The highest hourly minor/major approach volumes as shown in the data for Warrant 1.

(2) The signal warrant is satisfied when the conditions given below exist for one hour of an average day.

MUTCD Warrant Requirements

Warrant 3: Peak Hour - Condition B

The plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor street approach (one direction only) for 1 hour of an average day falls above the applicable curve in Figure 4C-3 for the existing combination of approach lanes.

NOTE:

This signal warrant shall only be applied in unusual cases. Such cases include, but are not limited to, office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.

Option:

If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the itnersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-4 may be used in place of Figure 4C-3.

Signal Warrant Analysis for NE 51st Street / 154th Ave NE

Warrant 7 - Crash Experience

Section 4C.08 Warrant 7, Crash Experience

Support:

01 The Crash Experience signal warrant conditions are intended for application where the severity and frequency of crashes are the principal reasons to consider installing a traffic control signal.

Standard:

02 **The need for a traffic control signal shall be considered if an engineering study finds that all of the following criteria are met:**

- **A. Adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency; and**
- **B. Five or more reported crashes, of types susceptible to correction by a traffic control signal, have occurred within a 12-month period, each crash involving personal injury or property damage apparently exceeding the applicable requirements for a reportable crash; and**
- **C. For each of any 8 hours of an average day, the vehicles per hour (vph) given in both of the 80 percent columns of Condition A in Table 4C-1 (see Section 4C.02), or the vph in both of the 80 percent columns of Condition B in Table 4C-1 exists on the major-street and the higher-volume minor-street approach, respectively, to the intersection, or the volume of pedestrian traffic is not less than 80 percent of the requirements specified in the Pedestrian Volume warrant. These major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be on the same approach during each of the 8 hours.**

WARRANT MET (1) = NO